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6-15-1998

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High Speed Imaging with an AGFA Consumer Grade Digital Camera

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I had been toying with the idea of purchasing a digital camera for some time and when the resolution of the sensors approached a million pixels and the cost dropped below $1K I decided to take the plunge and invest in one.

The camera I chose was one that I felt could be "adapted" for a variety of purposes, much like I have adapted my conventional, film, cameras for unusual tasks and uses. Granted that I could have bought specialized equipment to perform each of the tasks I had in mind but doing this would go against my "experimental" nature.

Among the applications I wanted to explore was the use of the camera as a film scanner, to allow me to photograph slides and negatives with the eventual purpose of using these images on my webpages or to send them as attachments to e-mail. Another application I wanted to explore was the use of the camera on a microscope or telescope to capture images made by these instruments. Another situation I wanted to explore was the use of the camera in my high speed photography lab to capture events "frozen in action" by the light of a 1 millionth of a second electronic flash. Finally, of course, I also wanted to get involved with a digital camera to make personal images or snapshots.

Eventually I decided on an Agfa ePhoto 1280 with a 1:3 ratio f/2.8-3.5 zoom lens, a liquid crystal display, an "equivalent" film speed of 100 and a maximum resolution of 1280x960 after PhotoGenie(TM) processing (a non-linear artificial intelligence based reconstruction program). With a maximum CCD resolution of 1024x768, the color depth is 30 bit in, 24 bit out. In a **previous article** I covered the adaptation of focal length converters, close-up lenses and the use of the camera for making copies of 35mm slides and negatives as well as its use as a storage and display device for presentation graphics. This article is an update concentrating on using it for ultra-high speed applications.

High speed photography actually implies two things. One is that one is setting out to make photographs of fast moving events and the other is that one wishes to make sharp and blur free photographs of these subjects. A conventional subject for truly high speed photography is a free-flying .22 caliber bullet and its impact on various objects.

If one attempts to make a photograph of such an event it quickly becomes obvious that the major problems one will have to solve are the achievement of exposures times that essentially prevent the subject from appearing blurred in the final photograph and the synchronization of the camera exposure with the bullet being at a particular time and location in space.

Deciding on an exposure time necessary to achieve blur free photographs is dependent on the amount of blur one can tolerate before calling the photo unsharp and the rate of travel of the subject. In the case of a .22 bullet moving at about 1,000 feet or 12,000 inches per second and assuming that we desired to limit movement of that bullet to less than 1/100 of an inch, the exposure time required would be 1/100 inch divided by the rate of motion of the bullet or 12,000 inches per second giving us a desired exposure time of about 1/1,000,000 second.

Obviously the Agfa 1280 does not meet this requirement. Its shortest exposure time is 1/500 second and even its flash, when operating, is hardly shorter than this. Therefore, to achieve truly short exposure times an auxiliary exposing device is required. An EG&G 549-11 "Microflash" electronic flash with a .5 microsecond duration will amply meet the requirements but it would need to be triggered by the camera somehow. This is actually not a problem and it could be done by simply slaving the Microflash to the camera's electronic flash. However, the camera's flash would overpower the Microflash and thus something would need to be done to "separate" the two light sources.

A problem that surfaces with the above "solution" is that the camera needs to be triggered in response to the event happening (the gun going off) and since the camera does not have a triggering device built-in other than the red, finger activated, shutter button one would have to depend on human reaction time to fire the camera which would itself have to have a very short reaction time and all this would have to be initiated in response to the gun going off. A highly unlikely situation for success!

However, that is not the only problem we face when attempting to use this camera for microflash work. This second problem is the fact that the Agfa camera's shutter is open a maximum of 1/4 second in Automatic mode and 1/8 second in Manual mode. This means that the event, the bullet striking some object, must happen during this "time window". The gun must be fired preferably at the beginning of the camera's shuttering action but, in any case, not later than the time it takes the bullet to travel across the field of view of the camera once the bullet has been fired. Ultimately one discovers that the consequence of the above constraint is that the camera, without human intervention, must somehow fire the gun as the shutter opens and the exposure starts.

Accomplishing this depends onthe camera providing some signal that the shutter is open or is about to open. It would seem that the firing of the camera's flash would give such a signal. Unfortunately the camera's synchronization scheme is such that when the flash is used either in automatic or fill mode the flash is fired at the very end of the exposure. This is called "second curtain" or "tailflash" synchronization. Trying to make the gun firing depend on the flash operating is thus impossible because the flash happens just before the exposure is over.

In the "redeye reduction" mode, however, the pre-flash happens a significant time before the camera's flash goes off and _this_ signal can be used to activate a light sensitive, delay equipped, synchronizer which then activates a solenoid hooked up to pull the trigger of the gun at the command of the synchronizer.

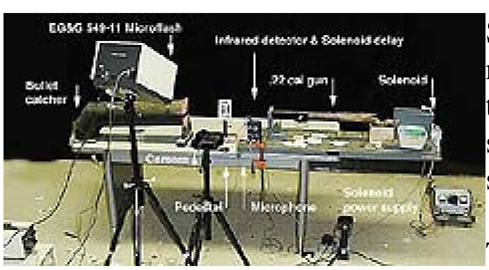
In my high speed photography classes my students and I make just such a synchronizer and you can find the schematics for the analog, 556 IC chip based, device we make at the following website: http://www.rit.edu/~andpph/text-cross-beam.html

As the experiment is assembled it becomes apparent that so far only some of the problems associated with making an ultra-high-speed photograph have been solved. These are the identification of a short duration flash and the firing of the gun by the action of the camera's pre-flash.

The delay provided by the synchronizer obviously needs to be adjusted in such a manner that the gun is fired just as the shutter in the camera opens. Then, as the bullet flies towards the bullet stop and across the field of view of the camera, a sound synchronizer, an accessory provided with the EG&G flash unit, picks up the bullet's shock wave or sound of the gun going off, and fires the Microflash. In terms of the length of time that the shutter is open, even at 1/8 second (which I chose using the camera in "manual exposure" mode), the bullet would be able to travel close to 100 feet before the shutter closed.

Therefore, the "time window" provided by the shutter is plenty long enough since normally one would not exceed a distance of more than 2-5 feet between the gun muzzle and the impact zone. It takes the bullet less than 1/200 second to travel this distance. In terms of 1/8 of a second, 1/200 is almost an eternity!

Anyway, now that the triggering of the gun can be initiated by the camera's pre-flash, it becomes obvious one needs to separate the "main" light flash of the camera from the action-stopping light produced by the EG&G Microflash unit. This is done by placing a visually opaque but infrared transparent filter over the camera's flash. The infrared energy is able to pass through the filter and since the synchronizer's sensor is also infrared sensitive, as far as this device is concerned the triggering signal has hardly changed. But as far as imaging is concerned, since the camera is effectively filtered against infrared wavelengths, it does not respond to the flash of infrared energy transmitted by the filter when the camera's main flash goes off.



So far we have accomplished firing of the gun in response to the camera shutter opening and firing the flash when the bullet is at some location in space by appropriate placement and use of a sound synchronizer.

The final step in the process is that of adjusting the delay of the synchronizer controlling the gun-firing solenoid and that responds to the initiation of the pre-flash from the camera. The process is one of adjusting the time delay until an image made by the Microflash unit is recorded by the camera. The best way to do this is to place the camera on the lowest resolution mode possible (307s) and choosing a fairly long delay to begin with. Since we will be using a long exposure time and ambient light would thus record an image on the camera's sensor, it is best to now operate under very dim ambient light. Now when the gun is fired it will be noted that by the time the Microflash goes off the camera's flash (a little light generally manages to leak through gaps) will already have fired.

At this point it is simply a matter of reducing the delay a little at a time until finally an image of a bullet in flight appears on the LCD screen after a firing. Because at low resolution the camera is capable of making many photographs without running out of storage space, many trials are possible ensuring that identifying the "right" time can probably be done without having to erase the camera's memory card.

I have also taken the approach of placing a mirror in the scene and aiming it in such a manner that it reflected an image of the microflash unit. When the image of the flash showed that it was fully lit up it was obvious that the flash was going off wile the shutter was open. This in turn meant that since the flash was fired by the flight of a bullet that the bullet itself would be visible in the photograph since the delay from the time the sound was detected and the firing of the flash was only in the order of microseconds.

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These are two examples of photographs made with the Agfa 1280. They are reduced and compressed for web display. The original sized files are available for more demanding uses such as printed reproductions. They are about 3 Mb files apiece.

There is a factor that I really did not deal with to any great extent and this is the one associated with proper exposure. Since this is a function of lens aperture, subject reflectance and, most significantly, flash output, I will simply say that the flash needs to be placed at such a distance that given the lens' maximum aperture, the amount of light falling on the scene during the 1/1,000,000 exposure time is sufficient to build up an appropriate signal level in the camera's CCD sensor. I found that the camera essentially duplicated the aperture called for with roughly 100 speed films. A more rigorous study of this is planned for the future but at this time it will have to suffice for me to say that there was no lack of light to achieve appropriate exposure.

As you can see the photographs made with the little Agfa 1280 rival those made with conventional film cameras although the resolution of the images is not quite the same. But with a file size (if I recall correctly) of about 800K JPEG compressed, or 3.5 Megs uncompressed in Photoshop, per image quite acceptable 5x7 inch hardcopy prints can be made. The big advantage of the digital camera is that the results of the shot are immediately visible in the camera's LCD screen. In this type of work, even if one has solved the technical problems associated with timing and position and synchronization, the problems associated with an effective _visual_ presentation, an image full of impact and with interesting arrangement of parts, still remain.

Since this is an unpredictable event the obvious solution is to make many photographs. With traditional photography one would not know what the final outcome would look like unless one took precautions to make Polaroid images along with those on conventional films. Or, one could simultaneously operate the Agfa camera with another loaded with film. The Agfa would provide an "instant", low cost, preview still suited for many applications, while for truly large enlargements the film image made by the conventional camera would be used. The best of both worlds!

My next project is to see what results can be obtained with my camera when it is attached to a microscope or other optical system. Stay tuned!

If you have questions or want to discuss any aspect of Agfa ePhoto 1280 applications fee free to write to me right HERE or later at andpph@rit.edu.